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Effect of Potassium Levels, Sources and Time of Application on Storage Life of Onion (*Allium cepa* L.)

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ABSTRACT

The present investigation on "Effect of potassium levels, sources and time of application on storage life of onion var. ArkaKalyan" was carried out at the College of Horticulture, Bagalkot, Karnataka during *Kharif* season crop of 2015 and 2016.The physiological loss in weight and rotting and sprouting of onion bulbs was minimum in 200 per cent RDK (19.25 and 13.91%, respectively) and maximum was recorded in 100 per cent RDK (23.40 and 18.13%, respectively). The marketable bulbs of onion was recorded highest in 200 per cent RDK (77.51%) and lowest marketable bulbs was recorded in 100 per cent RDK (71.96%) followed by 175 per cent RDK. The physiological loss in weight and rotting and sprouting of onion bulbs was minimum in potassium sources as SOP (21.12 and 15.09%) over MOP (22.60 and 16.50 per cent respectively). The marketable bulbs of onion was highest in potassium sources as SOP (76.01%, respectively) over MOP (74.43%). The increased marketable bulb yield and reduced the physiological loss in weight and rotting and sprouting onion bulb with the application 50 per cent potassium at transplanting and 50 per cent K at 30 DAT over 100 per cent potassium at transplanting.

Introduction

Onion (*Allium cepa* L.) is one of the important commercial bulbous crops cultivated extensively in India and it belongs to the family Alliaceae. It is a most widely grown and popular crop among the *Alliums*. The primary centre of origin of onion lies in Central Asia (Vavilov, 1951) and the near East and the Mediterranean regions are the secondary centres of origin. It is an ancient crop utilized in medicine, rituals and as a food in Egypt and in India since 600 BC. References of onion as food were also found in Bible and Quran. Onion bulb is strongly contracted subterranean shoot with thickened, fleshy leaves as food organ. The bulb is composed of carbohydrates (11.0 g), proteins (1.2 g), fibre (0.6 g), moisture (86.8 g) and energy (38 cal.), vitamins like ascorbic acid (11 mg), thiamine (0.08 mg), riboflavin (0.01 mg) and niacin (0.2 mg) and minerals like phosphorus (39 mg), calcium (27 mg), sodium (1.0 mg), iron (0.7 mg) and potassium (1.57

mg) per 100 g edible portion (Rahman *et al.*, 2013). Onion is mainly used for its flavour and pungency. The component which is responsible for pungency in onion is an alkaloid "Allyl propyl disulphide".

India is the second largest producer of onion in the world next to china, accounting 22.60 per cent of the world production. In India, onion is being grown in an area of 12.03 lakh ha with the annual production of 194.01 lakh MT and the productivity is 16.10 MT ha^{-1}. Among onion growing states Maharashtra stands first followed by Karnataka, Gujarat, Bihar, Madhya Pradesh, Andhra Pradesh, Rajasthan, Haryana, Uttar Pradesh and Tamil Nadu. In Karnataka, onion is cultivated in an area of 1.36 lakh hectare with production of 20.65 lakh tones and the average productivity is 15.10 MT ha^{-1} (Anon., 2015), which is low compared to world average. This illustrates the poor productivity and shelf life of onions produced during *kharif.* Several factors *viz.*, lack of suitable varieties, poor nutrient management practices and improper storage techniques have been identified as major causes for poor productivity, quality and storability of *kharif*onion. Onion being semi-perishable crop gets deteriorated during storage, transportation and marketing. Due to storage losses, it cannot be guaranteed that whole amount of the total production is consumed by the people.

The onion produce is available in market during October-November (20%) as *kharif* crop, January-February (20%) as late *kharif* crop and April-May (60%) as *rabi* crop. The *rabi*crop harvested in April-May is stored all over the country and slowly made available for domestic supply as well as for export up to October-November. There is a critical gap in supply in the country from October-December and as a result the prices shoot up. The good harvest in *kharif* season tries to bridge the gap. If there is failure of *kharif* crop due to vagaries of monsoon further rise the prices. The *kharif* crop therefore is more sensitive and vulnerable, yet essential. This is the critical period in the whole country, where there isno fresh harvest of onions and hence, storage assumes paramount importance for steady supply. Nearly two million tonnes need to be stored during this period (Tripathi and Lawande, 2003).Being high in water content, onion is a delicate commodity to store. Serious losses occur due to rotting, sprouting, physiological loss in weight and moisture evaporation. Therefore, the crop requires special procedure and parameters for storage. But, due to non-availability of appropriate post-harvest storage facilities, 25-30% of the total onions produced are wasted and it amounts to crores of rupees (Chopra, 2010). In general, the losses due to reduction in weight, sprouting and rotting were found to be 20 to 25 per cent, 4 to 8 per cent and 8 to 12 per cent respectively (Sharma, *et al.*, 2012).

Stage of harvesting plays a major role in determining the shelf life of onions as it is linked with physiological maturity of bulbs. The onion bulbs are cured either in field or in open shade or by artificial means before storage. During *kharif* season, bulbs are cured for 2-3 weeks along with top. In *rabi*, bulbs are cured in field for 3-5 days, tops are cut leaving 2-2.5 cm above bulb and again cured for 7-10 days in shade to remove field heat (Gopalakrishnan, 2010).

The present investigation is alarmed with the objectives. To study the effect of different methods of application, sources, potassium levels on storage life of onion.

Materials and Methods

The present investigation on “Effect of potassium levels, sources and time of application on storage life of onion var. ArkaKalyan” was carried out at the College of

Horticulture, Bagalkot, Karnataka during *Kharif* season of 2015 and 2016. The details of the materials used and the techniques adopted during the investigation are outlined in this chapter. Bagalkot is situated in the Northern Dry Zone (Zone-3) of Karnataka. The centre is located at 75° 42' East longitude and 16° 10' North latitude with an altitude of 542.00 m above Mean Sea Level (MSL). The district is grouped under arid and semi-arid region with mean annual rainfall of 517.3 mm and mean temperature of 32.6°C.The soil of the experimental site was red sandysoil.

Experimental details

Treatments: 20 (5 × 2 × 2)
Design: Factorial R.B.D
Replications: Three
Season: *Kharif*
Variety: ArkaKalyan
Spacing: 15 cm × 10 cm
Plot size: 2.1 m × 2.0 m
Fertilizer dose: 125: 75: 125 kg NPK ha^{-1}
Location: Haveli farm, COH, Bagalkot
Storage period: Three months under ambient condition

Treatment details

Factor I: Levels of potassium

100% RDK + RDNP&FYM (K_1)
125% RDK + RDNP&FYM (K_2)
150% RDK + RDNP&FYM (K_3)
175% RDK + RDNP&FYM (K_4)
200% RDK + RDNP&FYM (K_5)

Factor II: Sources of potassium: 1. MOP (S_1), 2. SOP (S_2)

Factor III: Time of application;

100% K at transplanting (T_1)
50% K at transplanting and 50% K at 30 DAT (T_2)

Note: Recommended dose of NP @ 125:75 kg and FYM @ 30 t ha^{-1} was applied commonly to all the treatments and nitrogen was applied 50 % at transplanting and 50 % at 30 days after transplanting.

The cured onion bulbs were sorted out and five kg healthy bulbs from each treatment were packed in thin gunny bag of size 45 x 60 cm and kept in laboratory for storage studies. The shelf life studies were conducted in the laboratory of Horticulture, University of Horticultural Sciences, Bagalkot. The onions after harvest was kept for curing along with the top under shade (in well ventilated room) for 8-10 days. Therefore the shelf life assessment of bulbs were selected randomly from three replications in the experiment. Then, from each treatment three replications were made consisting of five kg bulbs in each treatment. The observations were recorded from 15 days after storage to 90 days of storage at the interval of 30 days.

The details of the methodology adopted for recording these observations during experimentation are described below.

Physiological loss in weight (PLW %)

The loss in weight was obtained by taking difference between the weight of bulbs prior to storage and weight after storage taken every 30 days intervals for three months. The per cent reduction in the initial weight was computed by using following formula.

$$\text{PLW (\%)} = \frac{\text{Initial weight of bulbs} - \text{Final weight of bulbs}}{\text{Initial weight of bulbs}} \times 100$$

Sprouting (%)

For determining the sprouting percentage on stipulated days after storage, the bulbs showing a sprout were separated from the lot and weighed on an electronic balance. The sprouting percentage, which indicated the weight of the bulbs sprouted at 30, 60 and 90 DAS was calculated by using the formula given below.

$$\text{Sprouting (\%)} = \frac{\text{Weight of the sprouted bulbs}}{\text{Initial weight of the bulbs}} \times 100$$

Rotting (%)

For determining the rotting percentage on stipulated days after storage, the bulbs showing a rot were separated from the lot and weighed on an electronic balance. The rotting percentage, which indicated the weight of the bulbs rotten at 30, 60 and 90 DAS was calculated by using the formula given below.

$$\text{Rotting (\%)} = \frac{\text{Weight of the rotten bulbs}}{\text{Initial weight of the bulbs}} \times 100$$

Marketable bulbs (%)

At the end of each storage period at 30, 60 and 90 days after storage (DAS), the rotten and sprouted bulbs were separated and the weight of healthy bulbs was recorded. The recovery of marketable bulbs was calculated by using the following formula.

$$\text{Marketable bulbs (\%)} = \frac{\text{Weight of the healthy bulbs obtained}}{\text{Initial weight of the bulbs stored}} \times 100$$

Results and Discussion

Physiological loss in weight (%)

The data pertaining to physiological loss in weight (%) of onion bulbs recorded at 30, 60 and 90 days after storage (DAS) under ambient conditions during 2015, 2016 and pooled data are presented in Table 1.

Physiological loss in weight of onion bulbs at all the storage days differed significantly by potassium levels during both the years as well as in pooled data. At 30 DAS, the pooled data recorded the physiological loss in weight of onion bulbs was significantly minimum in 200% RDK (6.77 %) over 100%, 125% and 150% RDK (9.82, 8.68 and 8.23 %, respectively) but was on par with 175% RDK (7.31%) and maximum physiological loss in weight was recorded in 100% RDK. At 60 DAS, the minimum physiological loss in weight was recorded significantly in 200% RDK (15.47%) over 100%, 125%, 150 and 175% RDK (19.77, 18.99, 18.87 and 17.90, respectively) and maximum physiological loss in weight was observed in 100% RDK. At 90 DAS, the pooled data showed that the physiological loss in weight of onion bulbs was significantly minimum in 200% RDK (19.25%) over 100%, 125%, 150% and 175% RDK (23.40, 22.62, 22.50 and 21.53%, respectively) and maximum physiological loss in weight was recorded in 100% RDK.

Physiological loss in weight of onion bulbs varied significantly by potassium sources during both the years as well as in pooled data of onion storage. At 30 DAS, pooled data indicated that the physiological loss in weight of onion bulbs was significantly minimum in potassium sources as SOP (7.78%) over MOP (8.54%). At 60 and 90 DAS, in pooled data significantly minimum in potassium sources as SOP (17.43 and 21.12%, respectively) over MOP (18.97 and 22.60%, respectively).

Time of potassium application influenced the physiological loss in weight of onion bulbs during both the years and in pooled data. In pooled data, at 30 DAS, the minimum physiological loss in weight was recorded significantly with application of 50% potassium at transplanting and 50% at 30 DAT (7.87%) over 100 % potassium application at transplanting (8.45%). At 60 and 90 DAS, the minimum physiological loss in weight was recorded significantly by application of 50% potassium at transplanting and 50% at 30 DAT (17.72 and 21.38, respectively) over 100% potassium at transplanting (18.66 and 22.32%, respectively).

Interaction effects of potassium levels, sources and time of application on physiological loss in weight of onion bulbs differed significantly during both the years as well as in pooled data during 60 and 90 days after storage under ambient condition except 30 DAS. In pooled data at 60 DAS, the treatment combination of $K_5S_2T_2$ (200% RDK, SOP with application of 50% potassium at transplanting and 50% at 30 DAT) was recorded significantly minimum physiological loss in weight of onion bulbs (12.91%) over rest of the treatment combinations and maximum physiological loss in weight of onion bulbs was recorded in $K_1S_1T_1$ (21.79%). At 90 DAS, in pooled data, the treatment combination of $K_5S_2T_2$ (200% RDK, SOP with application of 50% potassium at transplanting and 50% at 30 DAT) was recorded significantly minimum physiological loss in weight of onion bulbs (16.84%) over rest of the treatment combinations and maximum physiological loss in weight of onion bulbs was recorded in $K_1S_1T_1$ (25.42%) but was on par with $K_5S_2T_1$ (17.64%).

Rotting and sprouting (%)

The data pertaining to rotting and sprouting (%) of onion bulbs recorded at 30, 60 and 90 days after storage (DAS) under ambient conditions during 2015, 2016 and pooled data are presented in Table 2.

Rotting and sprouting of onion bulbs at all the storage days differed significantly by potassium levels during both the years as well as in pooled data. At 30 DAS, in pooled data observed the rotting and sprouting of onion bulbs was significantly minimum in 200% RDK (2.01 %) over 100%, 125% 150% and 175% RDK (3.88, 3.31, 2.83 and 2.81%, respectively) and maximum rotting and sprouting was recorded in 100% RDK. At 60 DAS, the 200% RDK recorded significantly minimum rotting and sprouting (6.89%) over 100%, 125%, 150 and 175% RDK (9.42, 8.30, 8.00 and 7.63%, respectively) and maximum rotting and sprouting was observed in 100% RDK. At 90 DAS, the pooled data showed that the rotting and sprouting of onion bulbs was significantly minimum in 200% RDK (13.91%) over 100%, 125%, 150% and 175% RDK (18.13, 15.81, 15.47 and 15.64%, respectively) and maximum rotting and sprouting was recorded in 100% RDK.

Rotting and sprouting of onion bulbs varied significantly by potassium sources during both the years as well as in pooled data of onion storage. At 30, 60 and 90 DAS, in pooled data indicated that the rotting and sprouting of onion bulbs was significantly minimum in potassium sources as SOP (2.40, 7.86 and 15.09%, respectively) over MOP (3.54, 8.24 and 16.50%, respectively).

Time of potassium application influenced the rotting and sprouting of onion bulbs during both the years as well as in pooled data. In pooled data, at 30, 60 and 90 DAS, the minimum rotting and sprouting was recorded significantly with application of 50% potassium at transplanting and 50% at 30 DAT (2.58, 7.75 and 15.23%, respectively) over 100 % potassium application at transplanting (3.35, 8.33 and 16.35%, respectively).

Interaction effects of potassium levels, sources and time of application on rotting and sprouting of onion bulbs differed significantly at 60 days after storage except at 30 and 90 DAS. In pooled data at 60 DAS, the treatment combination of $K_5S_2T_2$ (200% RDK, SOP with application of 50% potassium at transplanting and 50% at 30 DAT) was recorded significantly minimum rotting and sprouting of onion bulbs (5.75%) over rest of the treatment combinations and maximum rotting and sprouting of onion bulbs was recorded in $K_1S_1T_1$ (10.81%). At 90 DAS, in pooled data, the treatment combination of $K_5S_2T_2$ (200% RDK, SOP with application of 50% potassium at transplanting and 50% at 30 DAT) was recorded minimum rotting and sprouting of onion bulbs (12.69%) over rest of the treatment combinations and maximum rotting and sprouting of onion bulbs was recorded in $K_1S_1T_1$ (19.58%).

Marketable bulbs (%)

The data pertaining to marketable bulbs (%) of onion recorded at 30, 60 and 90 days after storage (DAS) under ambient conditions during 2015, 2016 and pooled data are presented in Table 3.

Marketable bulbs of onion at all the storage days differed significantly by potassium levels during both the years as well as in pooled data. At 30 DAS, in pooled data recorded the marketable bulbs of onion was significantly highest in 200% RDK (89.74 %) over 100%, 125%, 150% and 175% RDK (85.52, 87.67, 88.03 and 88.31%, respectively) and significantly lowest marketable bulbs was recorded in 100% RDK.

At 60 DAS, 200% RDK recorded significantly highest marketable bulbs (84.35%) over 100%, 125% and 150% RDK (78.80, 81.22 and 82.83%, respectively) but was on par with 175% RDK (83.10%) and significantly lowest marketable bulbs was observed in 100% RDK. At 90 DAS, the pooled data showed that the marketable bulbs of onion was significantly highest in 200% RDK (77.51%) over 100%, 125% and 150% RDK (71.96, 74.39 and 76.00%, respectively) but was on par with 175% RDK (76.26%) andthe lowest marketable bulbs was recorded in 100% RDK.

Marketable bulbs of onion varied significantly by potassium sources during both the years as well as in pooled data of onion storage. At 30, 60 and 90 DAS, in pooled data indicated that the marketable bulbs of onion was significantly highest in potassium sources as SOP (88.67, 82.85 and 76.01%, respectively) over MOP (87.16, 81.27 and 74.43%, respectively).

Time of potassium application influenced the marketable bulb of onion during both the years as well as in pooled data. In pooled data at 30, 60 and 90 DAS, the highest marketable bulbs of onion was recorded significantly with application of 50% potassium at transplanting and 50% at 30 DAT (88.37, 82.39 and 75.55%, respectively) over 100 % potassium application at transplanting (87.46, 81.61 and 74.88%, respectively).

Interaction effects of potassium levels, sources and time of application on marketable bulbs of onion did not differ significantly during both the years and in pooled at 30, 60 and 90 days after storage. At 90 DAS, in pooled data, the treatment combination of $K_5S_2T_2$ (200% RDK, SOP with application of 50% potassium at transplanting and 50% at 30 DAT) was recorded minimum marketable bulbs of onion bulbs (79.09%) over rest of the treatment combinations and maximum marketable bulbs of onion was recorded in $K_1S_1T_1$ (70.36%).

Physiological loss in weight of onion bulbs at all the storage days differed significantly by potassium levels. At 30, 60 and 90 DAS, the physiological loss in weight of onion bulbs (pooled data) was significantly minimum in 200 per cent RDK (6.77, 15.47 and 19.25%, respectively) and maximum physiological loss in weight was recorded in 100 per cent RDK (9.82, 19.77 and 23.40%, respectively).

Table.1 Effect of potassium levels, sources and time of application on physiological loss in weight (PLW %) of onion var. ArkaKalyan stored under ambient condition

Treatment	Physiological loss in weight (%)								
	Day after storage (DAS)								
	30 DAS			60 DAS			90 DAS		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
Potassium levels (k)									
K_1-100 % RDK	9.69	9.94	9.82	19.72	19.82	19.77	23.51	23.29	23.40
K_2-125 % RDK	8.83	8.53	8.68	19.57	18.41	18.99	22.10	23.14	22.62
K_3-150 % RDK	8.42	8.05	8.23	19.47	18.27	18.87	21.96	23.04	22.50
K_4-175 % RDK	7.71	6.92	7.31	18.14	17.65	17.90	21.34	21.71	21.53
K_5-200 % RDK	6.93	6.60	6.77	15.77	15.16	15.47	18.85	19.66	19.25
S.Em±	**0.22**	**0.38**	**0.21**	**0.25**	**0.19**	**0.17**	**0.19**	**0.25**	**0.16**
C.D. (p= 0.05)	**0.64**	**1.10**	**0.59**	**0.73**	**0.55**	**0.49**	**0.55**	**0.72**	**0.46**
Potassium sources (S)									
S_1- Muriate of potash (MOP)	8.58	8.50	8.54	19.47	18.46	18.97	22.15	23.04	22.60
S_2- Sulphate of potash (SOP)	8.06	7.51	7.78	17.59	17.26	17.43	20.95	21.29	21.12
S.Em±	**0.14**	**0.24**	**0.13**	**0.16**	**0.12**	**0.11**	**0.12**	**0.16**	**0.10**
C.D. (p= 0.05)	**0.40**	**0.69**	**0.37**	**0.46**	**0.35**	**0.31**	**0.35**	**0.45**	**0.29**
Time of application (T)									
T_1- 100 % K at transplanting	8.52	8.37	8.45	19.12	18.20	18.66	21.89	22.76	22.32
T_2- 50 % K at transplanting & 50 % K at 30 DAT	8.10	7.64	7.87	17.93	17.51	17.72	21.20	21.56	21.38
S.Em±	**0.14**	**0.24**	**0.13**	**0.16**	**0.12**	**0.11**	**0.12**	**0.16**	**0.10**
C.D. (p= 0.05)	**0.40**	**0.69**	**0.37**	**0.46**	**0.35**	**0.31**	**0.35**	**0.45**	**0.29**
Interactions									
$K_1S_1T_1$	10.17	11.89	11.03	21.89	21.69	21.79	25.38	25.46	25.42
$K_1S_1T_2$	9.83	10.98	10.41	19.44	19.39	19.42	23.08	23.01	23.05
$K_1S_2T_1$	9.82	9.63	9.73	18.83	19.13	18.98	22.82	22.40	22.61
$K_1S_2T_2$	8.97	7.27	8.12	18.74	19.07	18.91	22.76	22.31	22.54
$K_2S_1T_1$	9.14	9.00	9.07	20.35	18.46	19.41	22.15	23.92	23.04
$K_2S_1T_2$	8.83	8.73	8.78	18.65	18.28	18.47	21.97	22.22	22.10
$K_2S_2T_1$	8.76	8.67	8.72	19.92	18.22	19.07	21.91	23.49	22.70
$K_2S_2T_2$	8.59	7.72	8.16	19.36	18.67	19.02	22.36	22.93	22.65
$K_3S_1T_1$	9.02	8.28	8.65	20.33	19.37	19.85	23.06	23.90	23.48
$K_3S_1T_2$	8.28	8.08	8.18	19.98	17.97	18.98	21.66	23.55	22.61
$K_3S_2T_1$	8.50	8.38	8.44	19.73	17.98	18.86	21.67	23.30	22.49
$K_3S_2T_2$	7.87	7.45	7.66	17.82	17.78	17.80	21.47	21.39	21.43
$K_4S_1T_1$	8.06	7.33	7.70	18.99	18.12	18.56	21.81	22.56	22.19
$K_4S_1T_2$	7.89	6.90	7.40	18.09	17.82	17.96	21.51	21.66	21.59
$K_4S_2T_1$	7.46	7.10	7.28	19.04	17.82	18.43	21.51	22.61	22.06
$K_4S_2T_2$	7.42	6.33	6.88	16.44	16.86	16.65	20.55	20.01	20.28
$K_5S_1T_1$	7.53	7.02	7.28	19.10	17.04	18.07	20.73	22.67	21.70
$K_5S_1T_2$	7.02	6.83	6.93	17.93	16.49	17.21	20.18	21.50	20.84
$K_5S_2T_1$	6.80	6.43	6.62	13.11	14.25	13.68	17.94	17.34	17.64
$K_5S_2T_2$	6.37	6.13	6.25	12.97	12.84	12.91	16.53	17.14	16.84
S.Em±	**0.45**	**0.77**	**0.41**	**0.51**	**0.39**	**0.34**	**0.39**	**0.50**	**0.32**
C.D. (p= 0.05)	**NS**	**NS**	**NS**	**1.46**	**1.11**	**0.98**	**1.11**	**NS**	**0.92**

DAT – Days after transplanting, DAS – Days after storage, NS-Non significant.
Note: Recommended dose of N:P at 125:75 kg and farmyard manure 30 t ha^{-1} was applied commonly to all the treatments and nitrogen was applied 50 % at transplanting and 50 % at 30 DAT.

Table.2 Effect of potassium levels, sources and time of application on rotting and sprouting (%) of onion var. ArkaKalyan stored under ambient condition

Treatment	Rotting and sprouting (%)								
	Day after storage (DAS)								
	30 DAS			60 DAS			90 DAS		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
Potassium levels (k)									
K_1-100 % RDK	3.33	4.43	3.88	9.57	9.27	9.42	17.02	19.25	18.13
K_2-125 % RDK	3.37	3.25	3.31	8.60	8.00	8.30	14.54	17.09	15.81
K_3-150 % RDK	3.06	2.60	2.83	8.20	7.80	8.00	14.48	16.47	15.47
K_4-175 % RDK	3.10	2.51	2.81	8.06	7.19	7.63	14.81	16.47	15.64
K_5-200 % RDK	2.04	1.99	2.01	6.91	6.87	6.89	12.81	15.00	13.91
S.Em±	**0.32**	**0.36**	**0.24**	**0.21**	**0.14**	**0.12**	**0.73**	**0.67**	**0.68**
C.D. (p= 0.05)	**0.93**	**1.03**	**0.67**	**0.60**	**0.41**	**0.35**	**2.10**	**1.92**	**1.94**
Potassium sources (S)									
S_1- Muriate of potash (MOP)	3.66	3.42	3.54	8.50	7.97	8.24	15.48	17.52	16.50
S_2- Sulphate of potash (SOP)	2.30	2.50	2.40	8.03	7.68	7.86	13.98	16.19	15.09
S.Em±	**0.21**	**0.23**	**0.15**	**0.13**	**0.09**	**0.08**	**0.46**	**0.42**	**0.43**
C.D. (p= 0.05)	**0.59**	**0.65**	**0.43**	**0.38**	**0.26**	**0.22**	**1.33**	**1.22**	**1.23**
Time of application (T)									
T_1- 100 % K at transplanting	3.39	3.30	3.35	8.62	8.04	8.33	15.31	17.39	16.35
T_2- 50 % K at transplanting & 50 % K at 30 DAT	2.56	2.60	2.58	7.91	7.59	7.75	14.14	16.31	15.23
S.Em±	**0.21**	**0.23**	**0.15**	**0.13**	**0.09**	**0.08**	**0.46**	**0.42**	**0.43**
C.D. (p= 0.05)	**0.59**	**0.65**	**0.43**	**0.38**	**0.26**	**0.22**	**NS**	**NS**	**NS**
Interactions									
$K_1S_1T_1$	4.51	5.55	5.03	11.32	10.30	10.81	18.34	20.82	19.58
$K_1S_1T_2$	3.93	4.46	4.20	10.12	9.78	9.95	17.31	19.80	18.56
$K_1S_2T_1$	2.93	4.10	3.52	8.38	8.52	8.45	17.03	18.50	17.77
$K_1S_2T_2$	1.97	3.61	2.79	8.46	8.46	8.46	15.38	17.87	16.63
$K_2S_1T_1$	4.88	4.05	4.47	10.36	7.66	9.01	15.79	17.80	16.80
$K_2S_1T_2$	3.01	2.95	2.98	6.98	7.42	7.20	14.24	16.72	15.48
$K_2S_2T_1$	3.07	3.33	3.20	8.62	8.74	8.68	14.25	17.47	15.86
$K_2S_2T_2$	2.51	2.67	2.59	8.46	8.18	8.32	13.87	16.35	15.11
$K_3S_1T_1$	4.07	3.07	3.57	7.50	8.57	8.04	14.91	17.39	16.15
$K_3S_1T_2$	4.04	2.61	3.33	7.42	5.87	6.65	15.65	17.04	16.35
$K_3S_2T_1$	2.11	2.72	2.42	9.08	8.28	8.68	14.98	16.57	15.78
$K_3S_2T_2$	2.05	2.02	2.04	8.80	8.46	8.63	12.38	14.86	13.62
$K_4S_1T_1$	4.72	3.67	4.20	8.54	6.80	7.67	15.89	17.82	16.86
$K_4S_1T_2$	2.71	2.50	2.61	8.14	7.84	7.99	15.51	16.43	15.97
$K_4S_2T_1$	2.67	2.14	2.41	8.88	7.19	8.04	14.95	16.74	15.85
$K_4S_2T_2$	2.31	1.74	2.03	6.67	6.93	6.80	12.91	14.88	13.90
$K_5S_1T_1$	2.97	3.00	2.99	6.80	7.75	7.28	14.31	16.14	15.23
$K_5S_1T_2$	1.80	2.33	2.07	7.84	7.70	7.77	12.85	15.18	14.02
$K_5S_2T_1$	2.05	1.41	1.73	6.81	6.71	6.76	12.72	14.67	13.70
$K_5S_2T_2$	1.36	1.20	1.28	6.18	5.32	5.75	11.37	14.00	12.69
S.Em±	**0.65**	**0.72**	**0.47**	**0.42**	**0.29**	**0.25**	**1.47**	**1.34**	**1.36**
C.D. (p= 0.05)	**NS**	**NS**	**NS**	**1.20**	**0.82**	**0.71**	**NS**	**NS**	**NS**

DAT – Days after transplanting, DAS – Days after storage, **Note:** Recommended dose of N:P at 125:75 kg and farmyard manure 30 t ha^{-1} was applied commonly to all the treatments and nitrogen was applied 50 % at transplanting and 50 % at 30 DAT.

Table.3 Effect of potassium levels, sources and time of application on marketable bulbs (%) of onion var. ArkaKalyan stored under ambient condition

Treatment	Marketable bulbs (%)								
	Day after storage (DAS)								
	30 DAS			60 DAS			90 DAS		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
Potassium levels (k)									
K_1-100 % RDK	87.16	84.49	85.52	79.13	78.47	78.80	71.76	72.17	71.96
K_2-125 % RDK	88.41	86.94	87.67	80.65	81.80	81.22	75.09	73.69	74.39
K_3-150 % RDK	88.47	87.59	88.03	82.20	83.47	82.83	76.76	75.23	76.00
K_4-175 % RDK	87.85	88.77	88.31	82.37	83.82	83.10	77.11	75.41	76.26
K_5-200 % RDK	90.03	89.45	89.74	83.81	84.88	84.35	78.17	76.85	77.51
S.Em±	**0.65**	**0.72**	**0.49**	**0.87**	**0.53**	**0.48**	**0.53**	**0.87**	**0.48**
C.D. (p= 0.05)	**1.86**	**2.07**	**1.40**	**2.49**	**1.53**	**1.37**	**1.53**	**2.49**	**1.37**
Potassium sources (S)									
S_1- Muriate of potash (MOP)	87.57	86.75	87.16	80.82	81.72	81.27	75.01	73.86	74.43
S_2- Sulphate of potash (SOP)	89.19	88.15	88.67	82.44	83.26	82.85	76.55	75.48	76.01
S.Em±	**0.41**	**0.46**	**0.31**	**0.55**	**0.34**	**0.30**	**0.34**	**0.55**	**0.30**
C.D. (p= 0.05)	**1.17**	**1.31**	**0.88**	**1.57**	**0.96**	**0.86**	**0.96**	**1.57**	**0.86**
Time of application (T)									
T_1- 100 % K at transplanting	87.89	87.03	87.46	81.25	82.18	81.61	75.47	74.29	74.88
T_2- 50 % K at transplanting & 50 % K at 30 DAT	88.87	87.86	88.37	81.99	82.79	82.39	76.08	75.03	75.55
S.Em±	**0.41**	**0.46**	**0.31**	**0.55**	**0.34**	**0.30**	**0.34**	**0.55**	**0.30**
C.D. (p= 0.05)	**NS**	**NS**	**0.88**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Interactions									
$K_1S_1T_1$	85.52	83.43	84.48	76.75	77.63	77.19	70.92	69.79	70.36
$K_1S_1T_2$	87.27	84.11	85.69	78.02	78.23	78.13	71.52	71.06	71.29
$K_1S_2T_1$	87.59	84.72	86.16	80.76	78.77	79.77	72.06	73.80	72.93
$K_1S_2T_2$	88.24	85.70	86.97	80.98	79.23	80.11	72.52	74.02	73.27
$K_2S_1T_1$	87.53	85.85	86.69	79.53	80.97	80.25	74.26	72.57	73.42
$K_2S_1T_2$	87.78	86.92	87.35	80.33	81.57	80.95	74.86	73.37	74.12
$K_2S_2T_1$	88.77	86.96	87.87	81.37	82.10	81.74	75.39	74.41	74.90
$K_2S_2T_2$	89.55	88.03	88.79	81.36	82.57	81.97	75.86	74.40	75.13
$K_3S_1T_1$	87.62	86.79	87.21	81.80	82.47	82.14	75.76	74.84	75.30
$K_3S_1T_2$	88.21	87.44	87.83	82.20	82.96	82.58	76.25	75.23	75.74
$K_3S_2T_1$	88.27	87.63	87.95	81.77	83.70	82.74	76.99	74.80	75.90
$K_3S_2T_2$	89.78	88.52	89.15	83.02	84.75	83.89	78.04	76.06	77.05
$K_4S_1T_1$	86.50	87.31	86.91	80.89	83.38	82.14	76.67	73.93	75.30
$K_4S_1T_2$	87.76	88.72	88.24	82.29	83.37	82.83	76.66	75.33	76.00
$K_4S_2T_1$	88.63	89.01	88.82	83.00	83.90	83.45	77.19	76.04	76.62
$K_4S_2T_2$	88.52	90.05	89.29	83.30	84.63	83.97	77.90	76.33	77.12
$K_5S_1T_1$	87.73	88.05	87.89	82.75	82.97	82.86	76.26	75.79	76.03
$K_5S_1T_2$	89.81	88.85	89.33	83.62	83.67	83.65	76.96	76.66	76.81
$K_5S_2T_1$	90.74	90.59	90.67	83.99	85.93	84.96	79.22	77.03	78.13
$K_5S_2T_2$	91.84	90.30	91.07	84.87	86.97	85.92	80.26	77.91	79.09
S.Em±	**1.30**	**1.45**	**0.98**	**1.74**	**1.07**	**0.96**	**1.07**	**1.74**	**0.96**
C.D. (p= 0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

DAT – Days after transplanting, DAS – Days after storage, NS-Non significant
Note: Recommended dose of N: P at 125:75 kg and farmyard manure 30 t ha^{-1} was applied commonly to all the treatments and nitrogen was applied 50 % at transplanting and 50 % at 30 DAT.

This might be due to higher level of potassium application resulted in low moisture content of onion bulbs and hence, there was a low physiological loss in weight during storage. Potassium increases the bulb cellulose, control plant turgidity, maintains integrity of the cell membranes and reduces water loss, reduce rotting and sprouting of bulbs. Similar observation were made by Gunjan *et al.,* (2005), and El-Sayed and El-Morsey (2012) and Poornima *et al.,* (2015).

Rotting and sprouting of onion bulbs at all the storage days differed significantly by potassium levels. At 30, 60 and 90 DAS, the rotting and sprouting of onion bulbs was recorded significantly minimum in 200 per cent RDK (2.01, 6.89 and 13.91%, respectively) over 100 per cent RDK (3.88, 9.42 and 18.13%, respectively). The rotting and sprouting of onion bulbs least with higher level of potassium application. This might be attributed to potential activity of potassium against the rotting and sprouting of onion bulbs. Potassium is as an essential element and it plays vital role in plant nutrition and reduce the water loss. Similar results were reported by Faten *et al.,* (2010) and Poornima *et al.,* (2015).

Marketable bulbs of onion differed significantly by potassium levels. The higher marketable bulb of onion was significantly in 200 per cent RDK and lowest marketable bulbs was recorded in 100 per cent RDK. The marketable bulbs of onion increased with levels of potassium application. Marketable bulb yield depends upon the how much extent of loss in weight, sprouting and rotting during storage. The increase in marketable bulbs yield might be due to low physiological loss in weight, rotting and sprouting of bulbs due to application of potassium. Similar results were reported by Hariyappa (2003), Gunjan *et al.,* (2005) and El-Sayed and El-Morsey (2012).

Physiological loss in weight of onion bulbs varied significantly by potassium sources during both the years as well as in pooled data of onion storage. At 30, 60 and 90 DAS, physiological loss in weight of onion bulbs was significantly minimum in potassium sources as SOP (7.78, 17.43 and 21.12%, respectively) over MOP (8.54, 18.97 and 22.60%, respectively). There was significant difference with respect to physiological loss in weight of onion during storage due to potassium sources such as sulphate of potash was recorded minimum PLW compared to MOP. Potassium sulphate increased bulbs cellulose, control plant turgidity, maintains integrity of the cell membranes and reduce the water loss. These results are in agreement with the finding of Ghulamnabi *et al.,* (2010).

Rotting and sprouting of onion bulbs varied significantly by potassium sources. At 30, 60 and 90 DAS, the rotting and sprouting of onion bulbs was significantly minimum in potassium sources as SOP (2.40, 7.86 and 15.09%, respectively) over MOP (3.54, 8.24 and 16.50 per cent, respectively). This results might be due to potassium source as sulphate of potash was attributed to potential activity of potassium against fungal diseases and rotting of the bulbs. These results are in agreement with the findings of Ghulamnabi *et al.,* (2010) and Deshpande *et al.,* (2013).

Marketable bulb of onion varied significantly by potassium sources. At 30, 60 and 90 DAS, the marketable bulb of onion was significantly highest in potassium sources as SOP (88.67, 82.85 and 76.01%, respectively) over MOP (87.16, 81.27 and 74.43%, respectively). The marketable bulb yield depends upon the how much extent of loss in weight, sprouting and rotting during storage. The highest marketable bulbs of onion due to application of sulphate of potash compared to muriate of potash. Similar findings have been reported by Gunjan *et al.,* (2005) and

Deshpande *et al.,* (2013). The result indicated that the significantly increased the marketable bulb yield and reduced the physiological loss in weight, rotting and sprouting onion bulbs and minimum moisture content of bulb during storage period of 90 days with the application 50 per cent potassium at transplanting and 50 per cent K at 30 DAT with recommended dose of nitrogen and phosphorus. The beneficial effect of potassium and sulphur present in sulphate of potash and split application resulting in reduced the PLW, rotting and sprouting and increased the marketable bulb yield during storage of onion bulbs under ambient condition. These findings are in agreement with the results of Gunjan *et al.,* (2005) and El-Sayed and El-Morsey (2012).

In pooled data at 60 and 90 DAS, the treatment combination of $K_5S_2T_2$ (200% RDK, SOP with application of 50 per cent potassium at transplanting and 50 per cent at 30 DAT) was recorded minimum physiological loss in weight of onion bulbs (12.91and 16.84%, respectively). There was significant difference with respect to physiological loss in weight in onion during storage due to potassium levels, sources such as sulphate of potash was recorded minimum PLW compared to MOP with split application of potash. This results may be due sulphur and potash present in SOP. Potassium sulphate increased bulbs cellulose, control plant turgidity, maintains integrity of the cell membranes and reduce the water loss. These results are in agreement with the finding of Desuki *et al.,* (2006), Ghulamnabi *et al.,* (2010).

In pooled data at 60 and 90 DAS, the treatment combination of $K_5S_2T_2$ (200% RDK, SOP with application of 50 per cent potassium at transplanting and 50 per cent at 30 DAT) was recorded significantly minimum rotting and sprouting of onion bulbs (5.75 and 12.69%, respectively). This results might be due to potassium levels, sources and split application. This was attributed to potential activity of potassium against fungal diseases and rotting of the bulbs. These results are in agreement with the finding of Ghulamnabi *et al.*, (2010) and Deshpande *et al.,* (2013).

At 90 DAS, the treatment combination of $K_5S_2T_2$ (200% RDK, SOP with application of 50 per cent potassium at transplanting and 50 per cent at 30 DAT) was recorded minimum marketable bulb of onion bulbs (79.09%). The marketable bulb yield depends upon the how much less losses in bulb yield. The highest marketable bulb of onion due to application potassium levels, sources such as sulphate of potash compared to muriate of potash and split application of potash. Similar findings have been reported by Hariyappa (2003), Gunjan *et al.*, (2005) and Deshpande *et al.*, (2013).

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